



US007952377B2

(12) **United States Patent**
Kister

(10) **Patent No.:** **US 7,952,377 B2**
(45) **Date of Patent:** ***May 31, 2011**

(54) **VERTICAL PROBE ARRAY ARRANGED TO PROVIDE SPACE TRANSFORMATION**

(75) Inventor: **January Kister**, Portola Valley, CA (US)

(73) Assignee: **MicroProbe, Inc.**, Carlsbad, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/419,912**

(22) Filed: **Apr. 7, 2009**

(65) **Prior Publication Data**

US 2009/0201041 A1 Aug. 13, 2009

Related U.S. Application Data

(63) Continuation of application No. 11/786,107, filed on Apr. 10, 2007, now Pat. No. 7,514,948.

(51) **Int. Cl.**

G01R 31/02 (2006.01)

G01R 31/00 (2006.01)

(52) **U.S. Cl.** **324/762.01**; 324/755.01; 324/755.04; 324/755.11

(58) **Field of Classification Search** 324/754, 324/761, 762; 439/862

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,518,612 A 6/1970 Dunman et al.
3,599,093 A 8/1971 Oates
3,710,251 A 1/1973 Hagge et al.
3,812,311 A 5/1974 Kvaternik

4,027,935 A 6/1977 Byrnes et al.
4,115,736 A 9/1978 Tracy
4,116,523 A 9/1978 Coberly et al.
4,423,376 A 12/1983 Byrnes et al.
4,525,697 A 6/1985 Jones et al.
4,532,423 A 7/1985 Tojo et al.
4,567,433 A 1/1986 Ohkubo et al.
4,593,961 A 6/1986 Cosmo
4,618,767 A 10/1986 Smith et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP 0764352 5/2004

(Continued)

OTHER PUBLICATIONS

Sporck, Nicholas, "A New Probe Card Technology Using Compliant Microsprings", *Proceedings 1997 IEEE International Test Conference*, Nov. 1, 1997, pp. 527-532.

(Continued)

Primary Examiner — Michael S Lebentritt

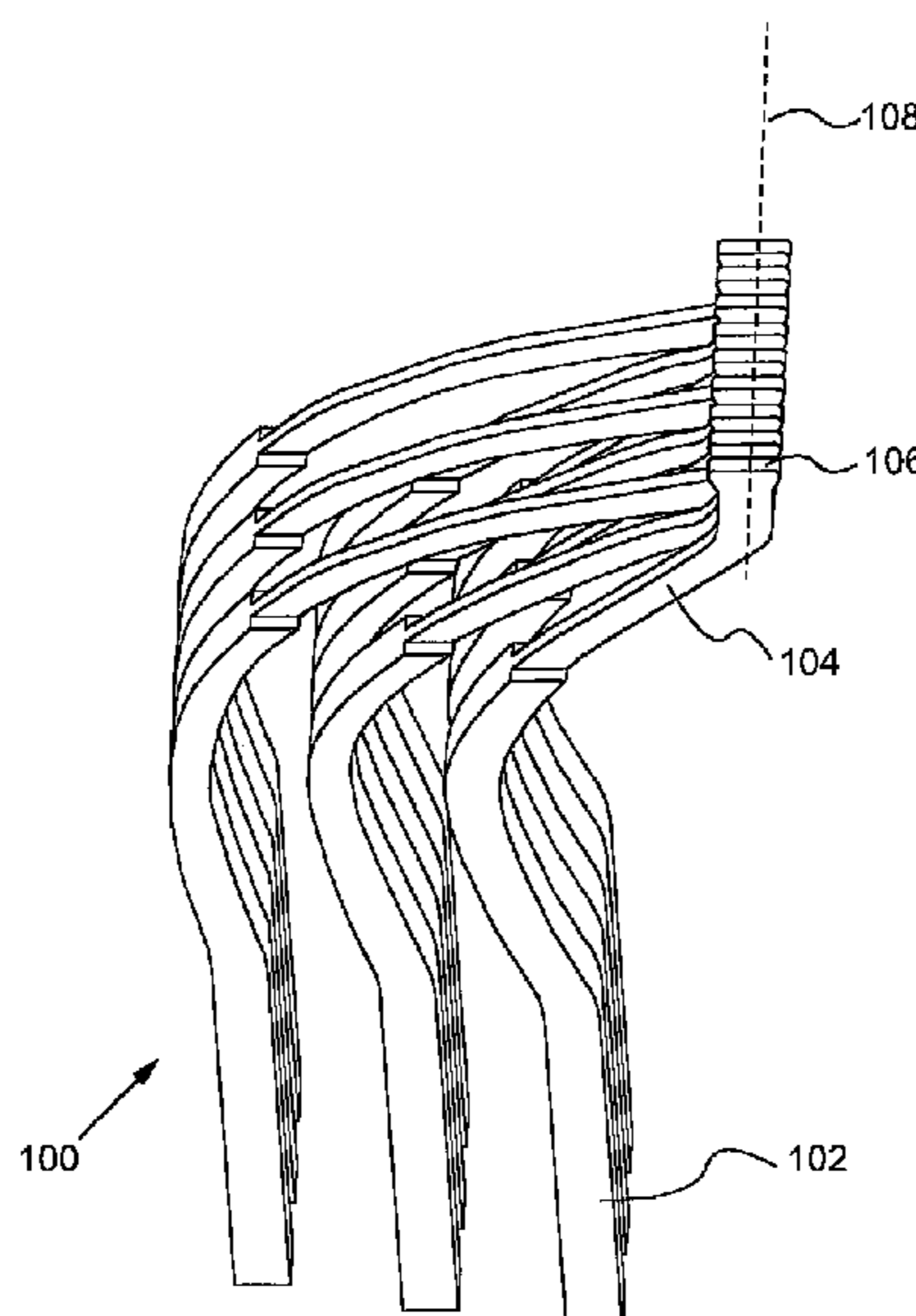
Assistant Examiner — Karen M Kusumakar

(74) *Attorney, Agent, or Firm* — Deborah A. Peacock; Samantha A. Updegraff; Peacock Myers, P.C.

(57) **ABSTRACT**

Improved probing of closely spaced contact pads is provided by an array of vertical probes having all of the probe tips aligned along a single contact line, while the probe bases are arranged in an array having two or more rows parallel to the contact line. With this arrangement of probes, the probe base thickness can be made greater than the contact pad spacing along the contact line, thereby advantageously increasing the lateral stiffness of the probes. The probe tip thickness is less than the contact pad spacing, so probes suitable for practicing the invention have a wide base section and a narrow tip section.

29 Claims, 4 Drawing Sheets



U.S. PATENT DOCUMENTS							
4,618,821	A	10/1986	Lenz	6,255,126	B1	7/2001	Mathieu et al.
4,706,019	A	11/1987	Richardson	6,259,261	B1	7/2001	Engelking et al.
4,730,158	A	3/1988	Kasai et al.	6,278,284	B1	8/2001	Mori et al.
4,747,698	A	5/1988	Wickramasinghe et al.	6,292,003	B1	9/2001	Fredrickson et al.
4,757,255	A	7/1988	Margozzi	6,336,269	B1	1/2002	Eldridge et al.
4,772,846	A	9/1988	Reeds	6,344,753	B1	2/2002	Takada et al.
4,773,877	A	9/1988	Kruger et al.	6,411,112	B1 *	6/2002	Das et al. 324/754
4,807,159	A	2/1989	Komatsu et al.	6,419,500	B1	7/2002	Kister
4,901,013	A	2/1990	Benedetto et al.	6,420,887	B1	7/2002	Kister et al.
4,967,148	A	10/1990	Doemens et al.	6,424,164	B1	7/2002	Kister
5,015,947	A	5/1991	Chism	6,433,571	B1	8/2002	Montoya
5,026,291	A	6/1991	David	6,437,584	B1	8/2002	Gleason et al.
5,030,318	A	7/1991	Reche	6,441,315	B1	8/2002	Eldridge et al.
5,061,192	A	10/1991	Chapin et al.	6,443,784	B1	9/2002	Kimoto
5,067,007	A	11/1991	Otsuka et al.	6,462,569	B2 *	10/2002	Chen 324/754
5,145,384	A	9/1992	Asakawa et al.	6,482,013	B2	11/2002	Eldridge et al.
5,205,739	A	4/1993	Malo et al.	6,486,689	B1	11/2002	Nishikawa
5,207,585	A	5/1993	Byrnes	6,525,552	B2	2/2003	Kister
5,225,771	A	7/1993	Leedy	6,529,021	B1	3/2003	Yu et al.
5,230,632	A	7/1993	Baumberger et al.	6,530,148	B1	3/2003	Kister
5,237,743	A	8/1993	Busacco et al.	6,566,898	B2	5/2003	Theissen et al.
5,354,205	A	10/1994	Feigenbaum et al.	6,570,396	B1	5/2003	Kister
5,399,982	A	3/1995	Driller	6,573,738	B1	6/2003	Matsuo et al.
5,422,574	A	6/1995	Kister	6,575,767	B2	6/2003	Satoh et al.
5,430,614	A	7/1995	Difrancesco	6,576,485	B2	6/2003	Zhou et al.
5,436,571	A	7/1995	Karasawa	6,586,955	B2	7/2003	Fjelstad et al.
5,476,211	A	12/1995	Khandros	6,615,485	B2	9/2003	Eldridge et al.
5,531,022	A	7/1996	Beaman et al.	6,624,648	B2	9/2003	Eldridge et al.
5,576,631	A	11/1996	Stowers et al.	6,633,176	B2	10/2003	Takemoto et al.
5,632,631	A	5/1997	Fjelstad et al.	6,641,430	B2	11/2003	Zhou et al.
5,635,846	A	6/1997	Beaman et al.	6,646,455	B2	11/2003	Maekawa et al.
5,644,249	A	7/1997	Kister	6,676,438	B2	1/2004	Zhou et al.
5,676,599	A	10/1997	Ricks et al.	6,677,245	B2	1/2004	Zhou et al.
5,720,098	A	2/1998	Kister	6,707,311	B2	3/2004	Hohenwarter
5,742,174	A	4/1998	Kister et al.	6,727,719	B2	4/2004	Liao et al.
5,751,157	A	5/1998	Kister	6,731,123	B2	5/2004	Kimoto
5,764,070	A	6/1998	Pedder	6,765,228	B2	7/2004	Lin et al.
5,764,072	A	6/1998	Kister	6,825,422	B2	11/2004	Eldridge et al.
5,764,409	A	6/1998	Colvin	6,842,023	B2	1/2005	Yoshida et al.
5,767,691	A	6/1998	Verkuil	6,847,221	B2	1/2005	Kimoto et al.
5,772,451	A	6/1998	Dozier, II et al.	6,853,208	B2	2/2005	Okubo et al.
5,773,987	A	6/1998	Montoya	6,881,974	B2	4/2005	Wood et al.
5,802,699	A	9/1998	Fjelstad et al.	6,890,185	B1	5/2005	Kister et al.
5,806,181	A	9/1998	Khandros et al.	6,897,666	B2	5/2005	Swettlen et al.
5,821,763	A	10/1998	Beamann et al.	D507,198	S	7/2005	Kister
5,829,128	A	11/1998	Eldridge et al.	6,917,102	B2	7/2005	Zhou et al.
5,832,601	A	11/1998	Eldridge et al.	6,917,525	B2	7/2005	Mok et al.
5,852,871	A	12/1998	Khandros	D510,043	S	9/2005	Kister
5,864,946	A	2/1999	Eldridge et al.	6,956,389	B1	10/2005	Mai
5,884,395	A	3/1999	Dabrowiecki et al.	6,965,244	B2	11/2005	Miller
5,892,539	A	4/1999	Colvin	6,965,245	B2	11/2005	Kister et al.
5,914,613	A	6/1999	Gleason et al.	6,970,005	B2	11/2005	Rincon et al.
5,917,707	A	6/1999	Khandros et al.	7,015,707	B2	3/2006	Cherian
5,923,178	A	7/1999	Higgins et al.	7,046,021	B2	5/2006	Kister
5,926,951	A	7/1999	Khandros et al.	7,059,865	B2	6/2006	Kister et al.
5,932,323	A	8/1999	Throssel	7,064,564	B2	6/2006	Kister et al.
5,934,914	A	8/1999	Fjelstad et al.	D525,207	S	7/2006	Kister et al.
5,936,421	A	8/1999	Stowers et al.	7,071,715	B2	7/2006	Shinde et al.
5,945,836	A	8/1999	Sayre et al.	7,073,254	B2	7/2006	Eldridge et al.
5,952,843	A	9/1999	Vinh	7,078,921	B2	7/2006	Haga et al.
5,969,533	A *	10/1999	Takagi 324/754	7,088,118	B2	8/2006	Liu et al.
5,970,167	A	10/1999	Colvin	7,091,729	B2	8/2006	Kister
5,974,662	A	11/1999	Eldridge et al.	7,109,731	B2	9/2006	Gleason et al.
5,994,152	A	11/1999	Khandros et al.	7,148,709	B2	12/2006	Kister
6,027,630	A	2/2000	Cohen	7,150,658	B1	12/2006	Chien
6,029,344	A	2/2000	Khandros et al.	7,173,441	B2	2/2007	Kister et al.
6,031,282	A	2/2000	Jones et al.	7,189,078	B2	3/2007	Kister et al.
6,064,215	A	5/2000	Kister	7,202,682	B2	4/2007	Cooper et al.
6,066,957	A	5/2000	Van Loan et al.	7,217,138	B2	5/2007	Kister et al.
6,071,630	A	6/2000	Tomaru et al.	7,218,127	B2	5/2007	Cooper et al.
6,086,386	A	7/2000	Fjelstad et al.	7,218,131	B2	5/2007	Tanioka et al.
6,133,072	A	10/2000	Fjelstad	7,225,538	B2	6/2007	Eldridge et al.
6,184,576	B1	2/2001	Jones et al.	7,227,371	B2	6/2007	Miller
6,204,674	B1	3/2001	Dabrowiecki et al.	7,265,565	B2	9/2007	Chen et al.
6,205,660	B1	3/2001	Fjelstad et al.	7,274,195	B2	9/2007	Takemoto et al.
6,215,320	B1	4/2001	Parrish	7,285,966	B2	10/2007	Lee et al.
6,218,203	B1	4/2001	Khoury et al.	7,312,617	B2	12/2007	Kister
6,247,228	B1	6/2001	Distefano et al.	7,345,492	B2	3/2008	Kister
				7,417,447	B2	8/2008	Kister

US 7,952,377 B2

Page 3

7,436,192 B2 10/2008 Kister
7,511,523 B2 3/2009 Chen et al.
7,514,948 B2 4/2009 Kister
7,649,367 B2 1/2010 Kister
7,659,739 B2 2/2010 Kister
7,676,559 B2 3/2010 Cuervo
2001/0012739 A1 8/2001 Grube et al.
2001/0040460 A1* 11/2001 Beaman et al. 324/754
2002/0070743 A1 6/2002 Felici et al.
2002/0125584 A1 9/2002 Umehara et al.
2002/0153913 A1 10/2002 Okubo et al.
2002/0194730 A1 12/2002 Shih et al.
2003/0016346 A1 1/2003 Umeda et al.
2004/0036493 A1 2/2004 Miller
2004/0104737 A1 6/2004 Haga et al.
2004/0119485 A1 6/2004 Koch et al.
2004/0239352 A1 12/2004 Mizoguchi
2005/0012513 A1 1/2005 Cheng
2005/0179458 A1 8/2005 Chen et al.
2005/0189955 A1 9/2005 Takemoto et al.
2006/0033516 A1 2/2006 Rincon et al.
2006/0073712 A1 4/2006 Suhir
2006/0082380 A1 4/2006 Tanioka et al.
2006/0170440 A1 8/2006 Sudin

2006/0171425 A1 8/2006 Lee et al.
2007/0167022 A1 7/2007 Tsai et al.
2008/0074132 A1* 3/2008 Fan et al. 324/762

FOREIGN PATENT DOCUMENTS

JP 63-307678 12/1988
JP 7-333232 12/1995
JP 10-506238 6/1998
JP 10-221374 8/1998
JP 11241690 8/1999
WO WO 8704568 7/1987
WO WO92/10010 6/1992
WO WO 96/15458 5/1996
WO WO96/37332 11/1996
WO WO97/43653 11/1997
WO WO01/09623 2/2001

OTHER PUBLICATIONS

Levy, Larry, "Water Probe TM System", *Southwest Workshop*
formfactor inc. Jun. 1997, 1-19.

* cited by examiner

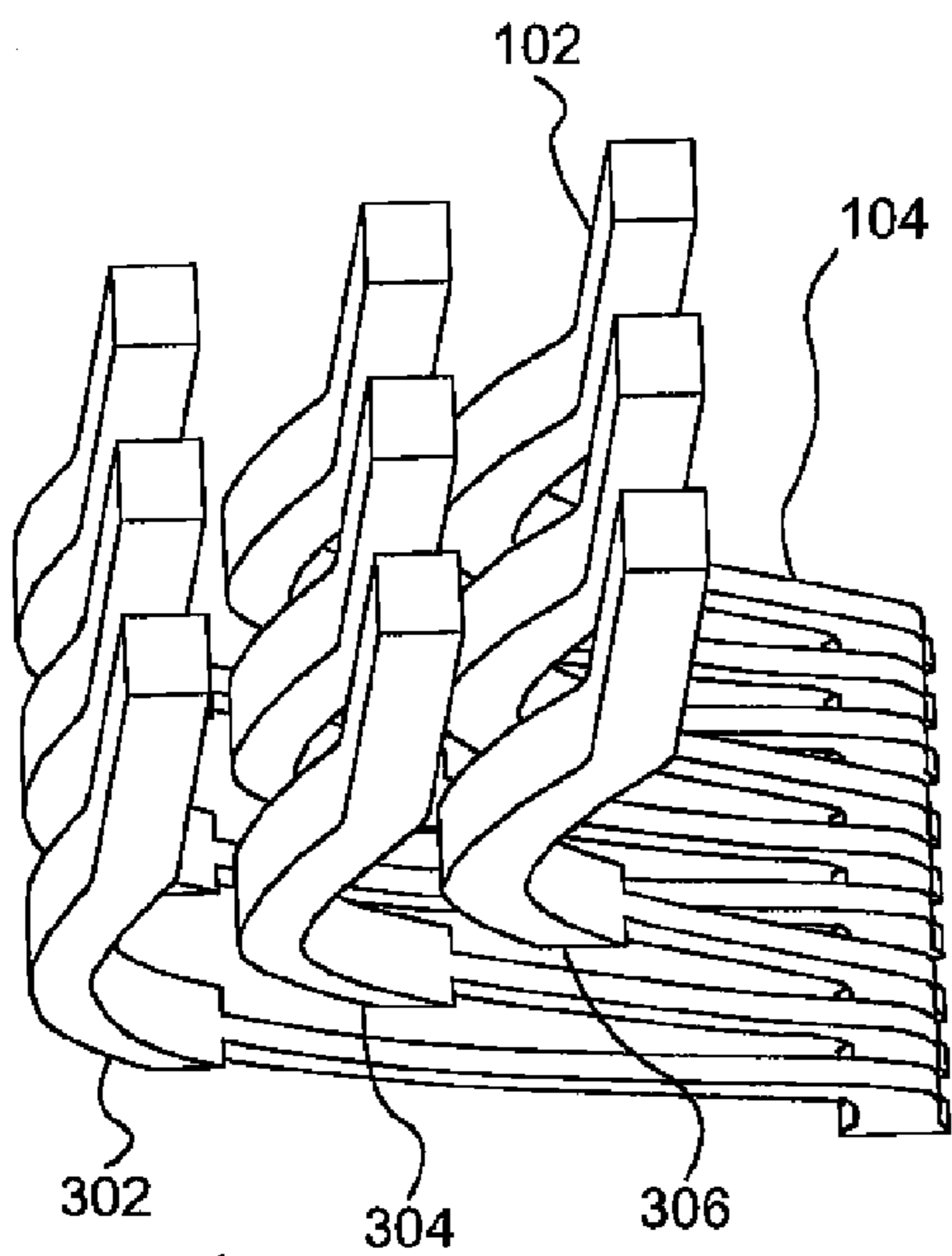


Fig. 1

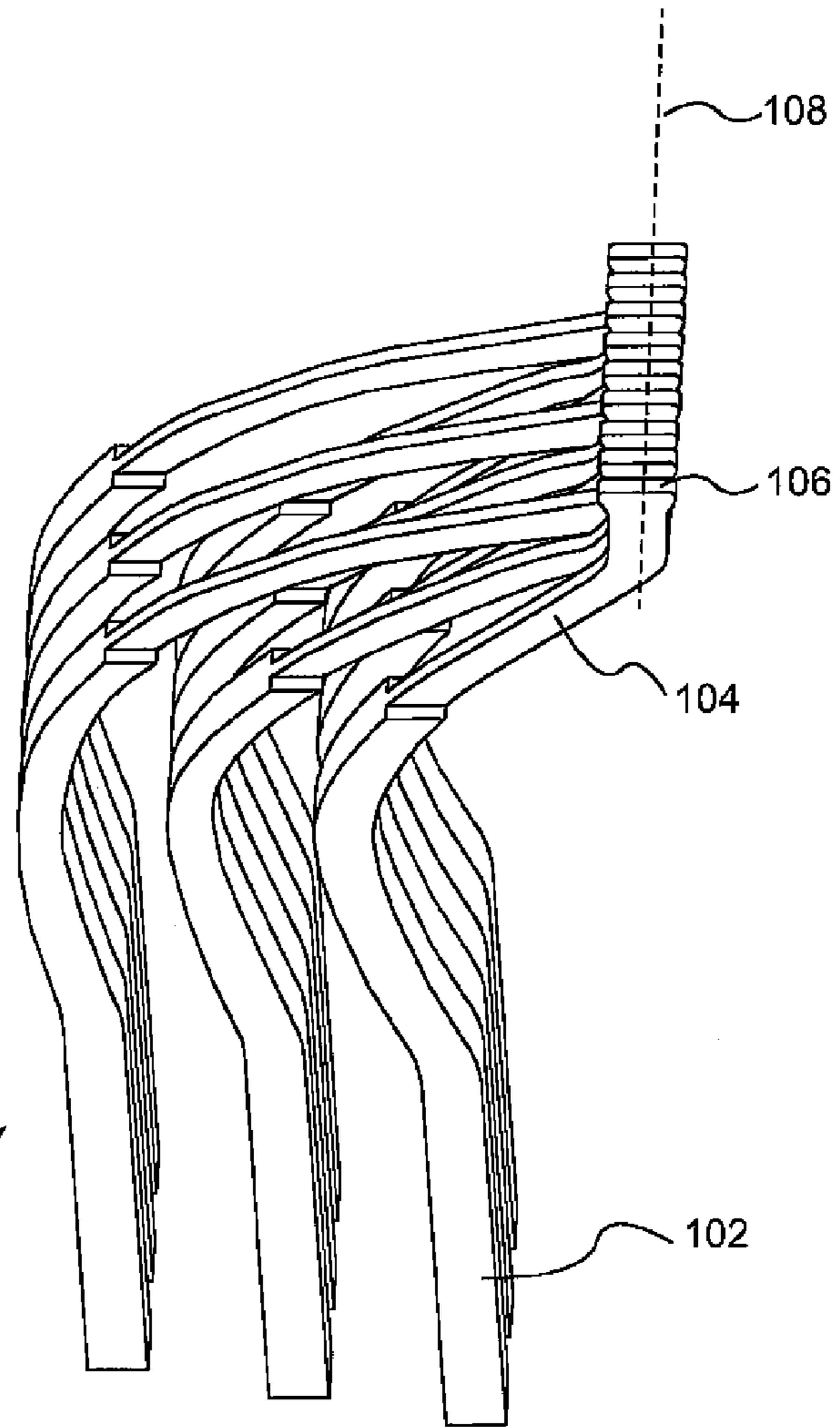
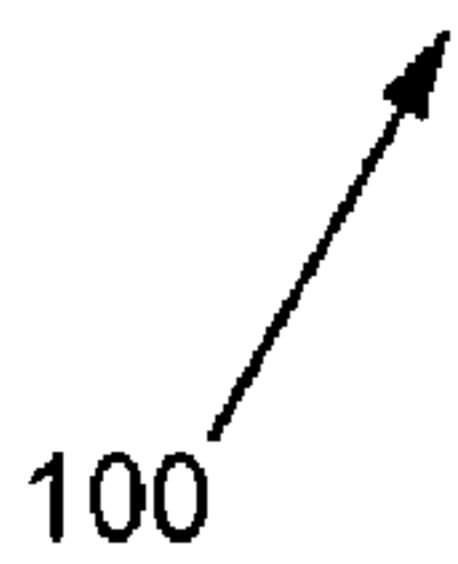


Fig. 2

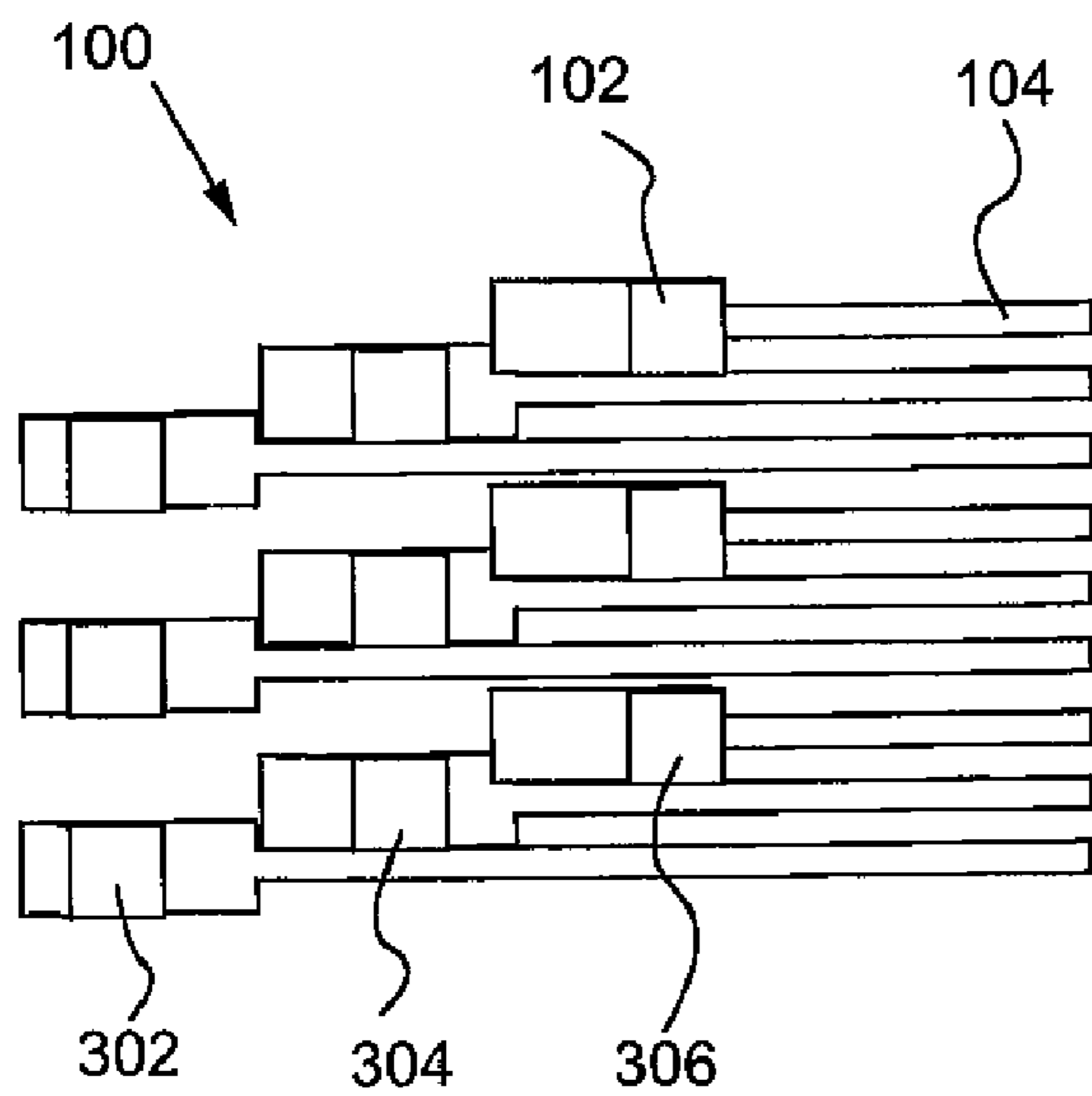


Fig. 3

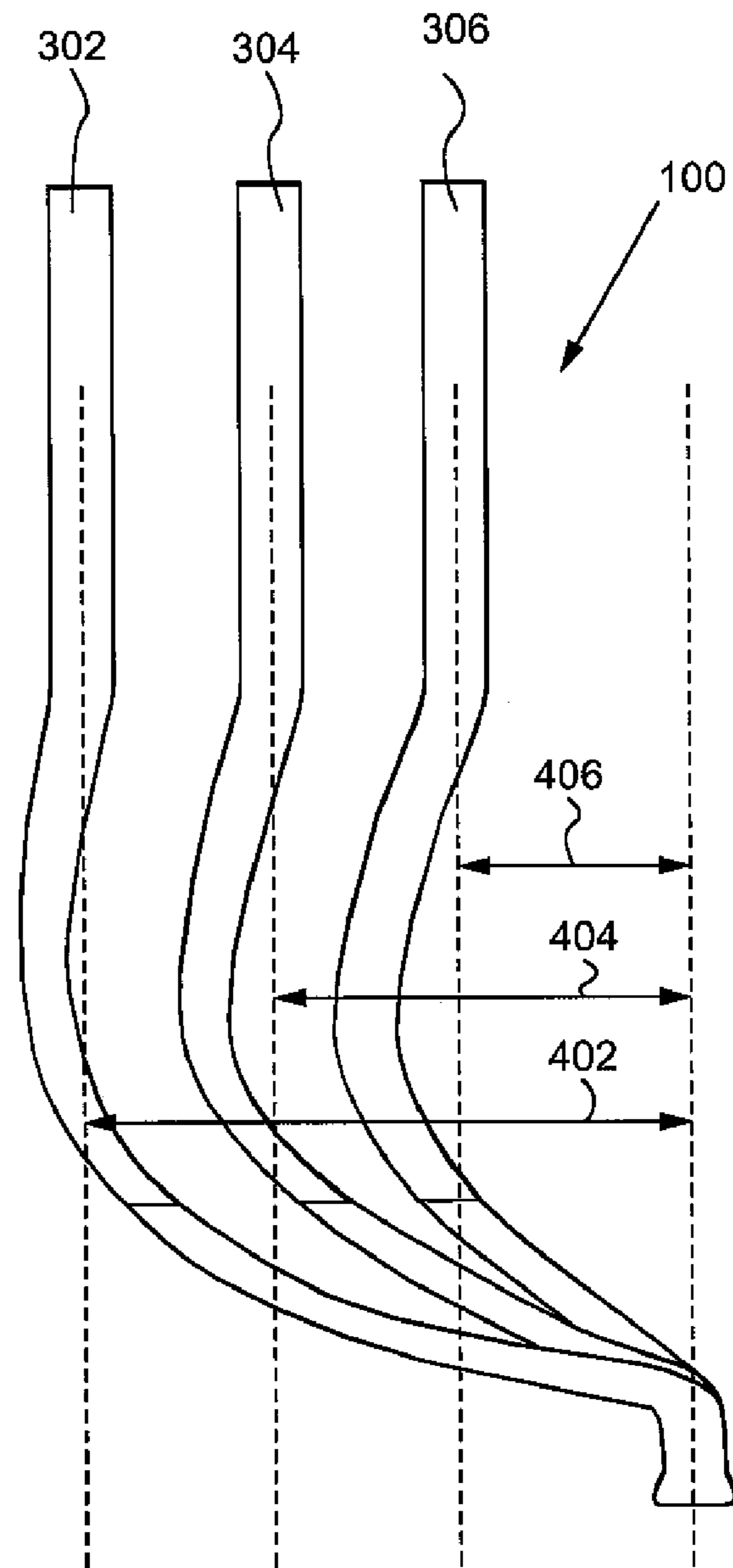


Fig. 4

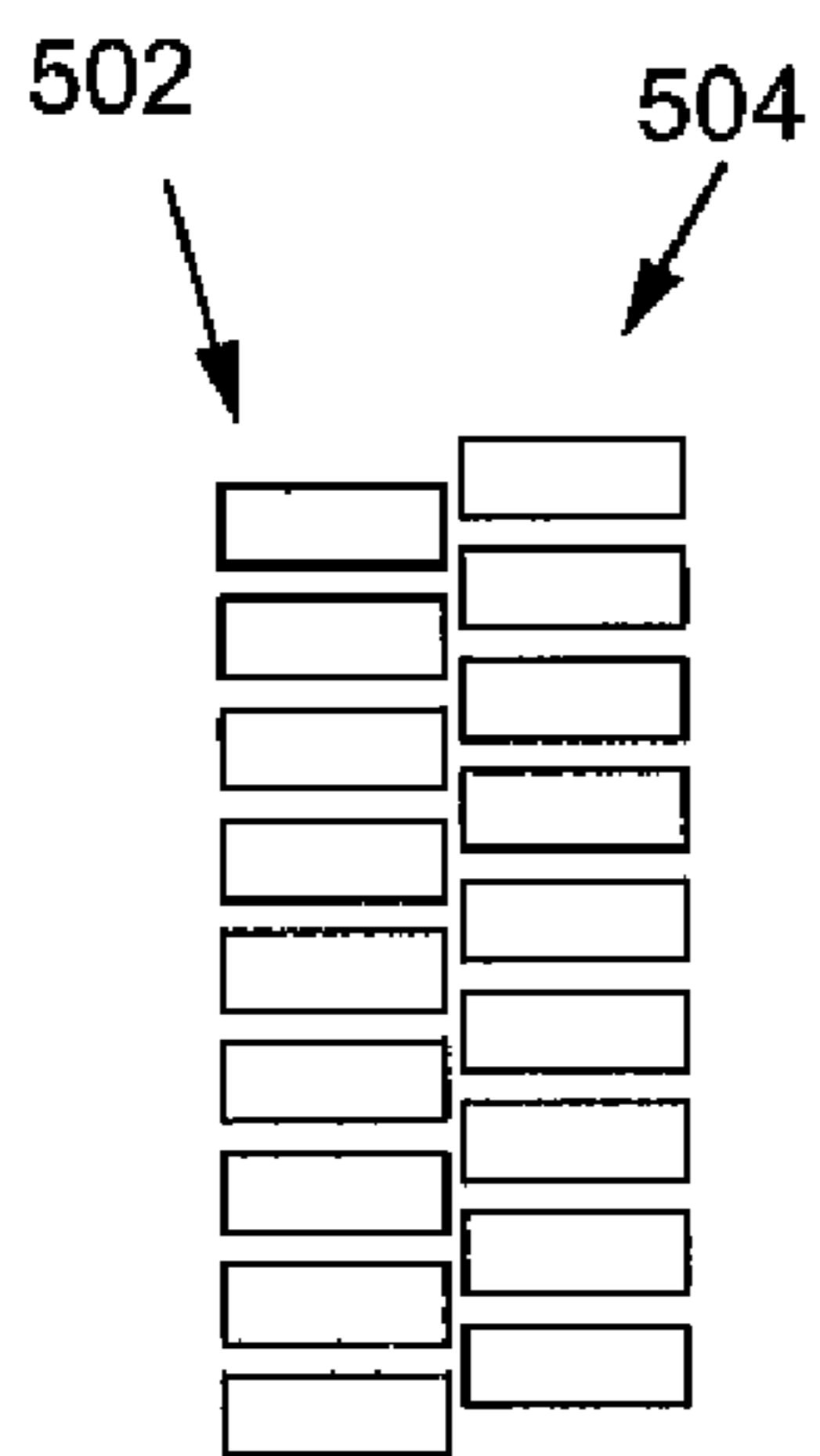


Fig. 5

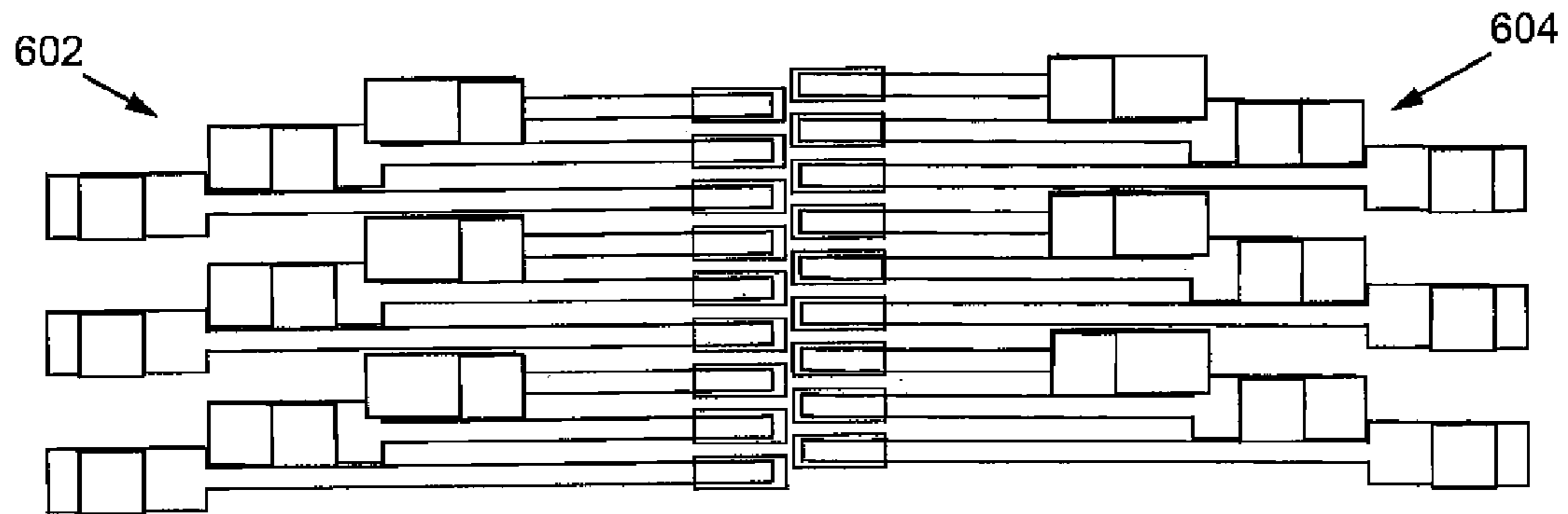


Fig. 6

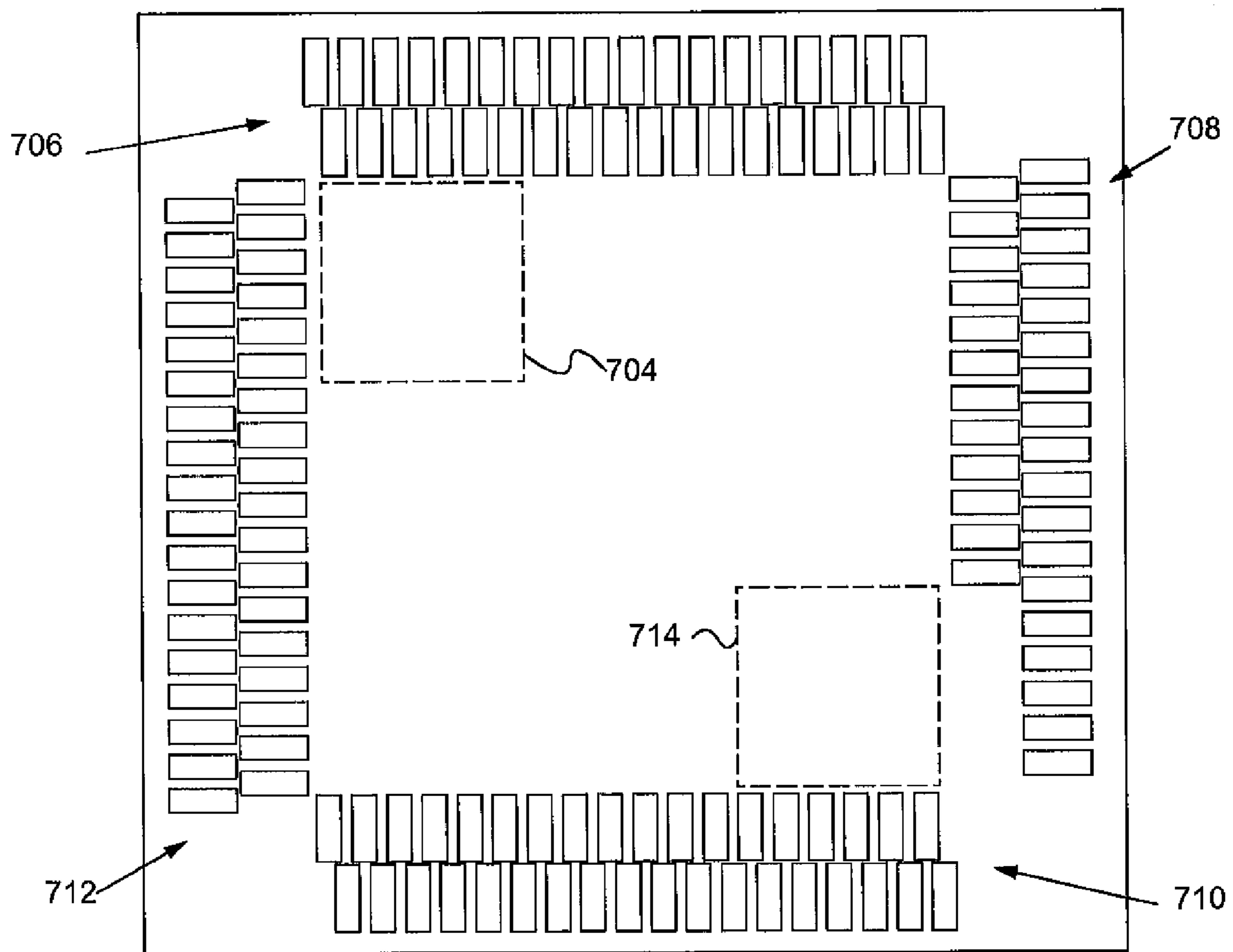


Fig. 7

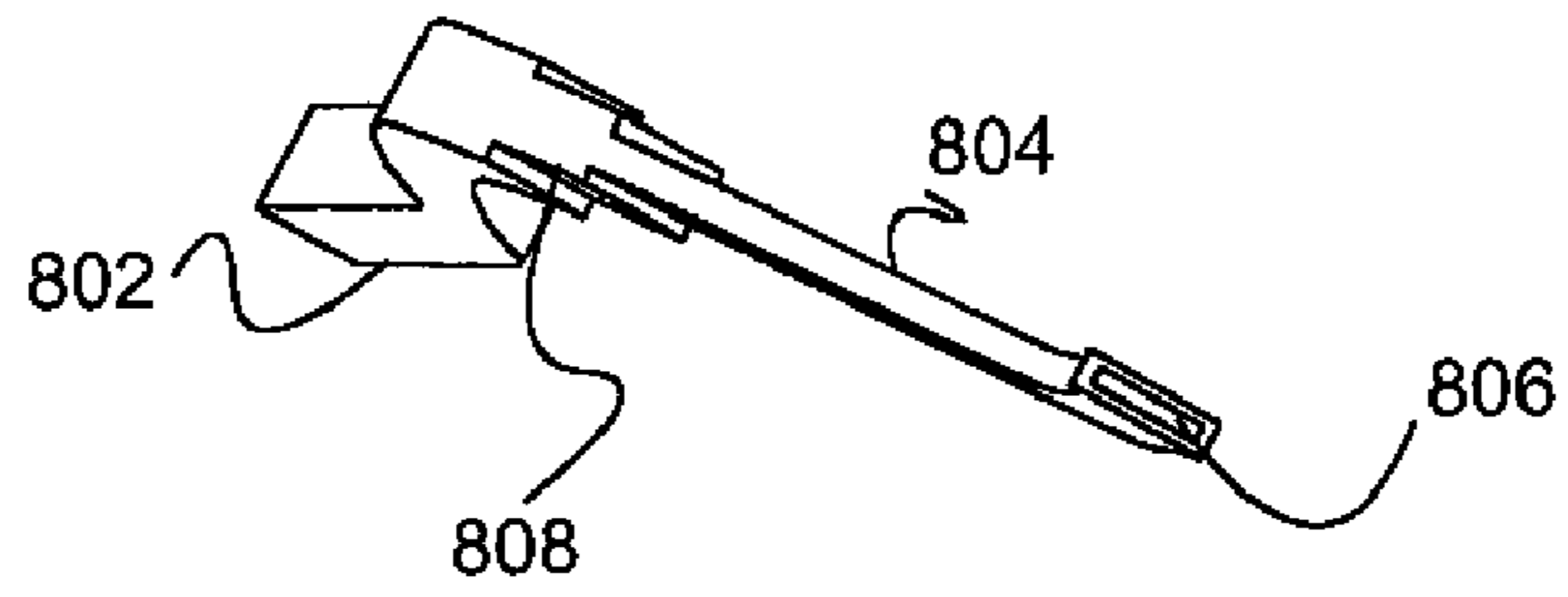


Fig. 8

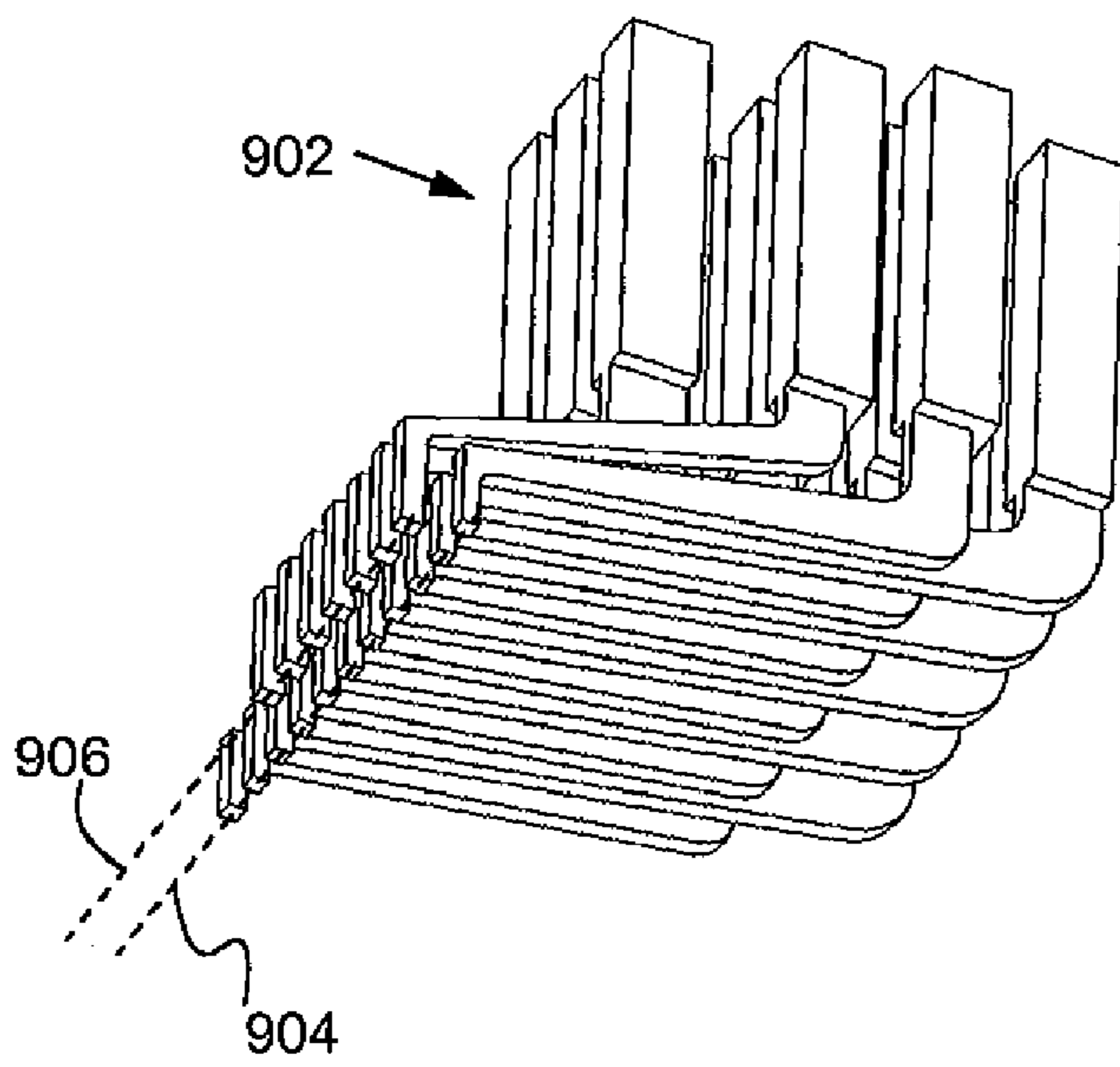


Fig. 9

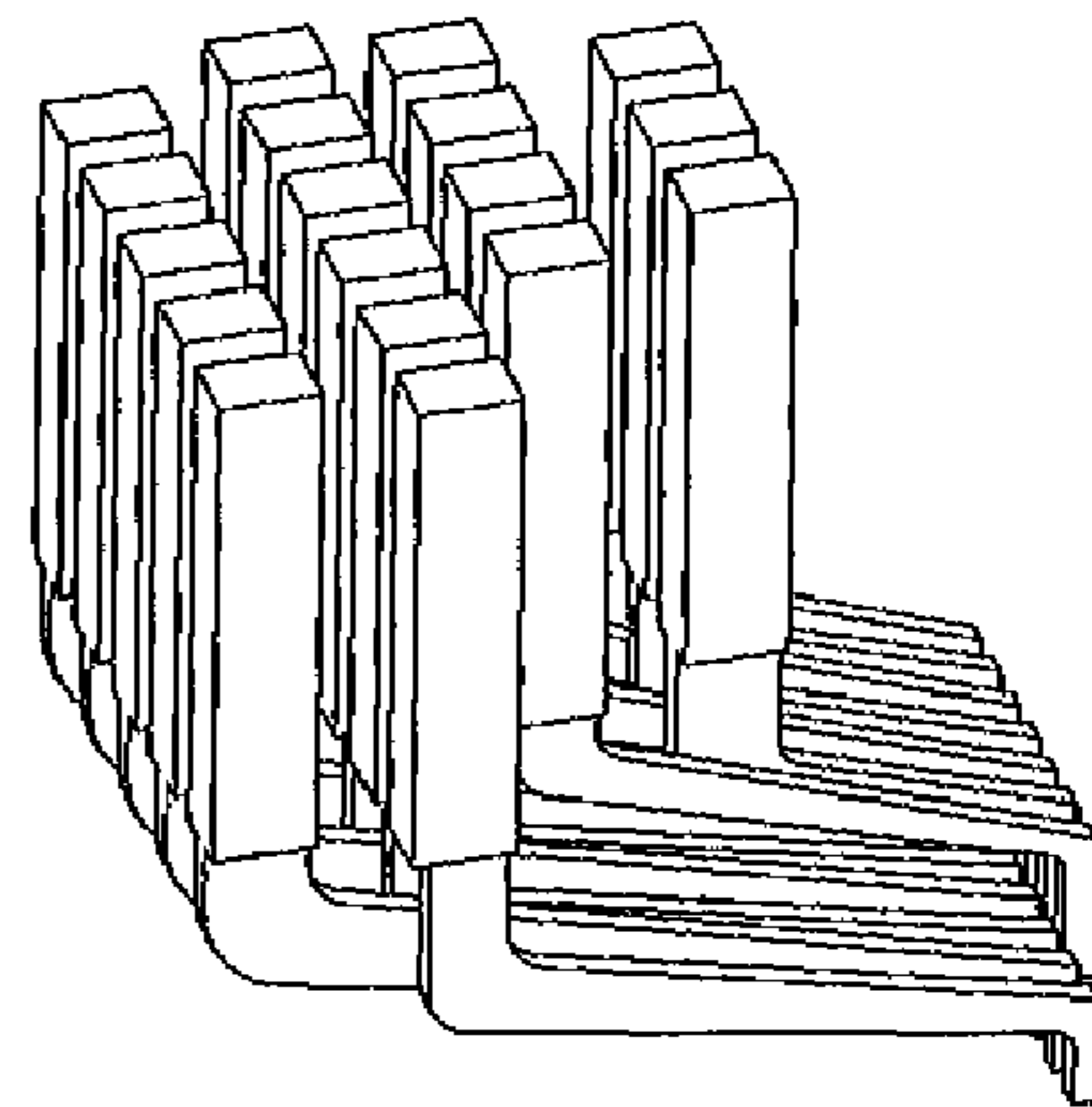


Fig. 10

1

VERTICAL PROBE ARRAY ARRANGED TO PROVIDE SPACE TRANSFORMATION

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation application of U.S. patent application Ser. No. 11/786,107 entitled "Vertical Probe Array Arranged to Provide Space Transformation", to January Kister, filed on Apr. 10, 2007, and the specification and claims thereof are incorporated herein by reference.

FIELD OF THE INVENTION

This invention relates to probe arrays for testing integrated electrical circuits.

BACKGROUND

Integrated electrical circuits are typically tested prior to final dicing and packaging. Such testing usually entails making temporary electrical contact to contact pads on the circuit or chip being tested. Probes or probe arrays are commonly employed to make such temporary electrical contact. Probes or probe arrays for this application have been under development for many years, since the ongoing technological evolution of chips and integrated circuitry to ever-smaller dimensions tends to raise problems which require new probing solutions.

For example, vertical probes have evolved significantly over time. In a vertical probe, at least a substantial portion of the probe is aligned along the vertical direction, where "vertical" is conventionally taken to the direction of probe travel when making contact. Vertical probes can provide improved control of scrub motion of the probe tip relative to the contact pad as contact is made, e.g., as described in U.S. Pat. No. 7,148,709 by the present inventor. Such improved control of scrub motion is increasingly important as contact pad dimensions decrease. Various aspects of arrays of vertical probes are also considered in U.S. Pat. No. 7,148,709, as well as in U.S. Pat. No. 6,443,784, U.S. Pat. No. 6,731,123, and U.S. Pat. No. 6,847,221.

Vertical probes often have a well-defined probe plane, such that deformation of the probe during contact occurs primarily in the probe plane without significant lateral (i.e. out of plane) motion. This situation is preferred in practice, because it allows an array of vertical probes to be closely spaced in a direction perpendicular to the probe plane, thereby facilitating making contact to a corresponding array of closely spaced contact pads. As long as the probe deformation is in-plane, undesirable contact between adjacent probes as a result of probe deformation during contact will not occur.

However, this approach can encounter difficulty as the contact pad spacing decreases, since decreased probe width (to accommodate the reduced contact pad spacing) can lead to an undesirable tendency of the probes to laterally deform. Such lateral probe deformation is highly undesirable, since it can lead to electrical contact between different probes of the same probe array.

Accordingly, it would be an advance in the art to provide probing of closely spaced contact pads with a vertical probe array having a reduced tendency for probes to laterally deform.

SUMMARY

Improved probing of closely spaced contact pads is provided by an array of vertical probes having all of the probe tips

2

aligned along a single contact line, while the probe bases are arranged in an array having two or more rows parallel to the contact line. With this arrangement of probes, the probe base thickness can be made greater than the contact pad spacing along the contact line, thereby advantageously increasing the lateral stiffness of the probes. The probe tip thickness is less than the contact pad spacing, so probes suitable for practicing the invention have a wide base section and a narrow tip section.

The invention is also suitable for probing two parallel rows of closely spaced contact pads. In such applications, the rows of contact pad may or may not be offset from each other. The invention is suitable for use with any kind or shape of vertical probe, provided the lateral probe thickness varies as described above. For example, knee probes can be employed where the probe tip is aligned with the probe base axis (i.e., the knee "goes out" as much as it "comes back in"), or where the probe tip is between the probe base axis and the knee (i.e., the knee goes out more than it comes back in), or where the probe base axis is between the probe tip and the knee (i.e., the knee goes out less than it comes back in).

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an oblique top view of a probe array according to an embodiment of the invention.

FIG. 2 shows an oblique bottom view of the probe array of FIG. 1.

FIG. 3 shows a top view of the probe array of FIG. 1.

FIG. 4 shows a side view of the probe array of FIG. 1.

FIG. 5 shows two rows of contact pads having an offset with respect to each other.

FIG. 6 shows an embodiment of the invention where contact is made to two staggered rows of contact pads as in FIG. 5.

FIG. 7 shows an example of an integrated electric circuit having staggered rows of contact pads.

FIG. 8 is an oblique bottom view of a probe suitable for use in another embodiment of the invention.

FIG. 9 is an oblique bottom view of a probe array suitable for use in yet another embodiment of the invention.

FIG. 10 is an oblique top view of the probe array of the embodiment of FIG. 9.

DETAILED DESCRIPTION

FIGS. 1-4 show various views of a probe array according to an embodiment of the invention. More specifically, FIG. 1 shows an oblique top view, FIG. 2 shows an oblique bottom view, FIG. 3 shows a top view, and FIG. 4 shows a side view. In these views, a probe array 100 includes several vertical probes, some of which are labeled as 302, 304, and 306. Each probe in the array has a base section (e.g., base section 102) and a tip section (e.g., tip section 104), where the base section and the tip section are at opposite ends of the probe. Each probe tip section has a tip contact surface (e.g., contact section 106) for making electrical contact to a device under test. The direction of probe base section motion as contact is made is vertical on FIG. 4 (i.e., parallel to the dotted lines of FIG. 4).

The tip sections of the probes are disposed such that the corresponding tip contact surfaces are disposed along a straight contact line (108 on FIG. 2). The base sections of the probes are disposed in a two-dimensional base array having at least two rows parallel to the contact line. In the example of FIGS. 1-4, there are three rows in the base array. A thickness of the base sections along the rows is substantially larger than

a center to center spacing of adjacent tip contact surfaces along the contact line (e.g., as shown on FIGS. 1-4). In this manner, closely spaced contact pads can be probed with a vertical probe array without requiring the entire length of the probes to have a thickness smaller than the contact pad spacing. Only the tip sections of the probes need to have such a small thickness. The base sections can be made thicker, which is advantageous for preventing lateral deformation (i.e., deformation in the direction of contact line 108) of probes when contact is made to the device under test. This arrangement of probes can be regarded as providing a space transformation function from a single row of contact pads to multiple rows in the base array.

Although it is not required, it is usually preferred for probes in each row of the base array to have the same shape. In this example, probes in the same row as probe 302 have the same shape as probe 302, probes in the same row as probe 304 have the same shape as probe 304, and probes in the same row as probe 306 have the same shape as probe 306. Since the distance between the rows of the base array and the contact line varies from row to row, probe shapes differ from row to row. Thus any two probes belonging to different rows of the base array will have different shapes.

To define how the probe shapes differ from row to row, it is helpful to define a tip to base offset for each probe. For example, FIG. 4 shows tip to base offsets 402, 404, and 406 for probes 302, 304, and 306 respectively. Adjacent rows have tip to base offsets which differ by the spacing between the adjacent rows, thereby providing alignment of the tips to a single contact line. For vertical knee probes, as in the example of FIGS. 1-4, it is important to note that the base to tip offset for a particular probe can be positive, zero, or negative. Without loss of generality, the tip to base offsets shown on FIG. 4 are taken to be positive. Thus a positive tip to base offset relates to a knee probe where the base axis is between the tip and the knee. Another way to describe a positive offset is that the knee "comes back in" further than it "goes out" as one moves from base to tip. Thus a negative tip to base offset relates to a situation where the knee "goes out" more than it "comes back in" as one moves from base to tip. The resulting probe configuration has the tip between the base axis and the knee. Finally, a tip offset of zero relates to the case where the tip and base axis are aligned.

Although the example of FIGS. 1-4 shows all probes having a positive tip to base offset, the invention can be practiced with probes have positive, negative and/or zero offset, provided the offsets vary from row to row as described above.

To provide uniformity of probing, it is preferred for each of the vertical probes in the probe array to provide substantially the same scrub motion between tip contact surface and the contact pad of the device under test as contact is made. The tip to base offset is an important parameter that can significantly affect the scrub motion of the probe, as described in greater detail in U.S. Pat. No. 7,148,709 and in U.S. patent application Ser. No. 11/450,977, both by the present inventor. However, vertical probe designs have other degrees of freedom for controlling the scrub motion in addition to the tip to base offset, so these other parameters can vary from row to row in such a way as to compensate for the effect of the different offsets for each row.

Embodiments of the invention are particularly suitable for probing closely spaced contact pads, since conventional vertical probing of such contact pads can encounter difficulties as described above. For example, in practicing the invention, the center to center spacing of the tip contact surfaces along the contact line can be from about 50 μm to about 100 μm . The

center to center spacing of the base sections along the rows of the base array is preferably between about 150 μm and about 200 μm .

It is preferred for each of the probes to deform primarily in a single plane, with minimal out-of plane deformation during contact. This probe plane (or deformation plane) is perpendicular to contact line 108 (i.e., it is the plane of FIG. 4). This property, which is enabled by the increased thickness of the base sections compared to the tip sections, is highly desirable for avoiding probe-to-probe electrical shorts during device test.

Although the preceding description relates to an example where a probe array according to an embodiment of the invention is configured to make contact to a single row of contact pads, the invention is also applicable to making contact to two or more rows of contact pads. For example, contact can be made to two rows of contact pads 502 and 504, as shown on FIG. 5. More specifically, FIG. 6 shows a top view of an embodiment of the invention where two probe arrays (602 and 604) are configured to make contact to two rows of contact pads (as on FIG. 5). Each row of contact pads has its corresponding array of probes, and each of these arrays provides a one row to multiple row space transformation as described above.

In making contact to multiple rows of contact pads according to embodiments of the invention, the rows of contact pads can have any arrangement relative to each other. However, devices under test often provide rows of contact pads that are parallel to each other, have the same contact pad spacing and are offset from each other by a tip row offset that is about half the contact pad spacing (e.g., as shown on FIG. 5). For example, contact pads having a spacing of about 50 μm to about 100 μm can have an offset of about 25 μm to about 50 μm . Thus a preferred embodiment of the invention provides corresponding probe arrays (e.g., as shown on FIG. 6).

FIG. 7 shows an example of an integrated electric circuit having staggered rows of contact pads. Circuit 702 includes 4 sets of contact pads, 706, 708, 710, and 712, each of which can be probed with a corresponding probe array as described above in connection with FIG. 6. In corner overlap regions, such as region 704, probes corresponding to one set of contact pads (e.g., set 706) may interfere with probes from another set of contact pads (e.g., set 712). If such interference is of concern, the affected contact pads can be probed by conventional methods that avoid probe interference, or the contact pads can be arranged to eliminate the interference. For example, probes for contact pad set 710 extend into corner overlap region 714, but contact pad set 708 is configured such that none of its corresponding probes need to extend into region 714. In this manner, interference between probes can be avoided in practicing the invention.

The preceding description is by way of example as opposed to limitation, so the invention can also be practiced according to many variations of the preceding embodiments. For example, it is not critical exactly how the probe thickness decreases in the transition from base section to tip section. A single abrupt transition as shown on FIGS. 1-4 is one possibility. FIG. 8 shows a probe having a base section 802, a tip section 804 and a base to tip transition region 808 to reduce stress concentration at the transitions and to increase overall probe stiffness. Such a "stepped taper" is compatible with layer by layer probe fabrication, which is preferred for fabricating probes according to embodiments of the invention. The example of FIG. 8 shows a stepped taper having two transitions. Any number of transitions in a stepped taper can be employed in practicing the invention.

5

In practicing the invention, details of the probe tip shape are also not critical. However, a “skate” (e.g., 806 on FIG. 8) on the tip contact surface having a narrower width than the probe tip is a preferred configuration compared to the full-width contact surface 106 of FIG. 2.

Details of the overall probe shape are also not critical in practicing the invention. FIGS. 9 and 10 show two views of a probe array according to an embodiment of the invention where the probes have straight vertical sections 902. In contrast, the example of FIGS. 1-4 shows probes having curved vertical sections. The example of FIGS. 9 and 10 also shows making contact to two rows of contact pads (i.e., along lines 904 and 906), as in the example of FIG. 6. However, the example of FIG. 6 shows the probe arrays arranged on opposite sides of the contact lines, while the example of FIGS. 9 and 10 shows the probe arrays arranged on the same side of the contact lines. This possibility provides another solution to the problem of possible probe interference as described in connection with FIG. 7, since sets of contact pads 706, 708, 710, and 712 can all be probed from outside the square they form.

Suitable materials for probes and probe tips to be included in probe arrays of the invention are well known in the art, and any such materials can be employed in practicing the invention. Suitable tip materials are electrically conductive and wear-resistant, and include Rh and Cr. Suitable probe fabrication, manufacturing, assembly and mounting methods for making probe arrays according to embodiments of the invention are also well known in the art.

What is claimed is:

1. A probe array comprising:
 - at least two rows of vertical probes;
 - said adjacent tip sections of the probes aligned along an axis comprising a first center to center spacing;
 - said adjacent base sections of the probes in each row comprising a second center to center spacing;
 - said second center to center spacing greater than said first center to center spacing; and
 - wherein said rows of probes are disposed on a same side of said axis.
2. The apparatus of claim 1 wherein said base sections comprise a thickness substantially larger than said center to center spacing of said adjacent tip sections.
3. The apparatus of claim 1 wherein said probe array contacts a contact surface and said rows of said probe array are parallel to a plurality of contact pads on the contact surface, wherein the contact pads are contacted by said tip sections.
4. The apparatus of claim 1 wherein said vertical probes comprise straight sections.
5. The apparatus of claim 1 wherein said vertical probes comprise curved sections.
6. The apparatus of claim 1 wherein said probes in each said row of said base array have a same shape.

6

7. The apparatus of claim 1 wherein said rows of probes have different shapes.

8. The apparatus of claim 1 wherein said probes provide a substantially same scrub motion on a contact surface.

9. The apparatus of claim 1 wherein said base sections are thicker than said tip sections.

10. The apparatus of claim 1 wherein said probes are vertical knee probes.

11. The apparatus of claim 1 wherein at least one probe has a positive base to tip offset.

12. The apparatus of claim 1 wherein at least one probe has a negative base to tip offset.

13. The apparatus of claim 1 wherein at least one probe has a zero base to tip offset.

14. The apparatus of claim 1 wherein a distance between said rows of said probe array vary from row to row.

15. The apparatus of claim 1 wherein said first center to center spacing of said tip sections is from about 50 μm to about 100 μm .

16. The apparatus of claim 1 wherein said second center to center spacing of said base sections is between about 150 μm to about 200 μm .

17. The apparatus of claim 1 wherein said probes deform primarily in a single plane.

18. The apparatus of claim 1 wherein said probes deform primarily in a single plane, said plane perpendicular to said axis.

19. The apparatus of claim 1 wherein said probes have minimal out-of-plane deformation during contact.

20. The apparatus of claim 1 wherein said probes contact a single row of contact pads on a contact surface.

21. The apparatus of claim 1 comprising multiple probe arrays for contacting multiple rows of contact pads on a contact surface.

22. The apparatus of claim 1 wherein said rows of said base array are staggered.

23. The apparatus of claim 1 wherein said probes contact a plurality of contact pads disposed in a corner of an integrated electric circuit.

24. The apparatus of claim 1 wherein said probes comprise at least one base to tip transition region.

25. The apparatus of claim 1 wherein each said tip section comprises a skate.

26. The apparatus of claim 25 wherein said skate comprises a narrower width than said tip section.

27. The apparatus of claim 1 wherein said tip sections comprise an electrically conductive and wear-resistant material.

28. The apparatus of claim 27 wherein said tip section comprises Rh.

29. The apparatus of claim 27 wherein said tip section comprises Cr.

* * * * *